Title	Performance recovery of rebar-corroded reinforced concrete beams repaired by cement mortar mixed with recycled nylon fibers from used fishing nets [an abstract of dissertation and a summary of dissertation review]
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Citation	北海道大学. 博士(工学) 甲第14306号
Issue Date	2020-12-25
Doc URL	http://hdl.handle.net/2115/80174
Rights(URL)	https://creativecommons.org/licenses/by/4.0/
Type	theses (doctoral - abstract and summary of review)
Additional Information	There are other files related to this item in HUSCAP. Check the above URL.
File Information	Teeranai_Srimahachota_abstract.pdf (論文内容の要旨)

学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　博士（工学）　氏名　Teeranai Srimahachota

学　位　論　文　題　名

Performance recovery of rebar-corroded reinforced concrete beams repaired by cement mortar mixed with recycled nylon fibers from used fishing nets
(廃棄漁網からのリサイクルナイロン繊維を混入したモルタル補修材料による鉄筋腐食コンクリートはりの性能回復効果)

Marine ecosystems are deteriorating due to derelict fishing gears (DFG) including fishing nets. Fishing nets that were discarded or lost in the ocean become traps, leading to the deaths to many of marine species especially sea lions, whales and turtles. It is estimated that 705,000 tons of DFG are lost in the ocean and kill more than 380,000 lives annually. It is also reported that entanglement of ships' propellers in DFG causes economic losses over 90 million USD in Korean Sea.

Fishing nets are usually made of very strong and durable materials, such as nylon, high-density polyethylene (HDPE) and polyamide, which are non-biodegradable. Even though many used fishing nets are recycled or utilized, applications of recycled fishing nets are still limited. In addition, recycling fishing nets, especially made of nylon, consumes lots of resources and energy, as well as emits greenhouse gases. Therefore, finding suitable solutions for collecting and recycling fishing nets is an urgent issue to mitigate environmental impact.

This research investigates the application of used fishing nets as reinforcement fibers in cement mortar from the viewpoints of mechanical properties and durability. Two main objectives were appointed, 1) application of recycled nylon fiber from used fishing nets (RN fiber) for the repair of corroded RC beams and 2) long-term durability of the mortar reinforced with the RN fibers subjected to the chloride ion ingress.

Four types of fiber were used as a reinforcing material in polymer cement mortar (PCM): two kinds of RN fiber from used fishing nets, manufactured fibrillated polyethylene (PE) microfiber, and manufactured polyvinyl alcohol (PVA) fiber. Reinforced concrete (RC) beams were placed in the tidal zone for 2 years to induce steel corrosion, then repairs were carried out by spraying PCM reinforced with those fibers on the repair section of the beams. The repairs were taken for the normal RC beams at the end of the exposure period. The upgraded RC beams underwent repair operations before starting the exposure and were not further repaired even after the exposure. Repairability of the RC beams was extensively investigated, such as load-carrying capacities after the repair, failure behavior, stain distributions, cracks formation, and chloride ion penetrability. The effectiveness of the reinforcement with RN fibers was compared with that of PE and PVA fibers. In addition, mechanical properties of the reinforced PCM as well as compatibility of RN fibers under high alkalinity in concrete were also studied.

Experimental results confirmed that RN fibers along with the manufactured PE microfiber and PVA fiber have great potential to be used as reinforcement in cement mortar and for the repair of lightly corroded RC beams. The addition of RN and PVA fibers seems to have no noticeable effect on the flowability of fresh PCM, but the addition of PE fiber results in a considerable reduction of flowability because of its geometry and the surface property.

Adding RN and PVA fibers does not show visible effect on the compressive strength, but the flexural capacity of the PCM is reduced. In contrast, adding PE fibers increases both the compressive and flexural strengths of PCM. It is concluded that fiber reinforcement contributes to post-peak flexural capacity and helps prevent abrupt failure. Flexural capacity of the RC beams that was deteriorated due to the corrosion of tensile rebar can be compensated with the sprayed PCM. The effectiveness of the RN fiber is comparable with that of the PVA fibers but inferior PE microfibers. Adding fibers helps distribute stresses throughout the beam under the bending load. RN fibers helps transfer stresses through wide cracks and spreads the cracks toward the support of the beams. PE fibers prevents severe damage of the beams by distributing damage from a wide crack to many small cracks. It is confirmed that RN fiber is stable under high alkalinity in mortar without any sign of deterioration; however, surface characteristics of RN fiber may cause poor bonding between fibers and mortar substrates.

For the long-term durability, mortar reinforced with RN and PE fibers subjected to chloride ion ingress were evaluated. RN fibers and PE fibers were mixed into ordinary Portland cement (OPC) mortar and PCM. Two groups of specimens were made: non-exposed specimens that were kept in laboratory and the specimens that were exposed to seawater for 3 months and 12 months. Chloride ion diffusion coefficients of non-exposed specimens were also evaluated using chloride migration tests. The spatial distribution of chloride ions, chloride penetration depth and the effective diffusion coefficient of exposed specimens were examined with electron probe microanalyzer (EPMA). Based on the chloride migration test, the effective diffusion coefficient of the reinforced mortar seems to be improved with the addition of RN and PE fibers, but the tendency is still unclear. The type of mortar mix (e.g. OPC or PCM) and water-to-binder ratio are still dominant factors to govern the effective diffusion coefficient of mortar. EPMA analysis results confirm that chloride ion penetration depth and chloride ion profile of exposed specimens are identical regardless of the type of fiber or fiber content. Changes in chloride ions ingress because of the addition of fiber seems to be negligible.

It is concluded that the recycled nylon fiber from used fishing nets tested in this study has been proven effective for reinforcing cementitious materials, and for repairing lightly corroded RC beams. RN fiber has comparable performance to that of the manufactured PVA and PR fibers. Application of recycled fiber for construction materials is a possible way to promote utilizing waste fishing nets.